CHAPTER V

V. WATER QUALITY AND AQUATIC ECOLOGY

A. Introduction

As part of the diagnostic phase of the Webster Lake Study, samples were collected at lake stations, each tributary to Sucker Brook and locations on Sucker Brook itself. Samples were analyzed for a number of chemical and biological parameters. Listed in Table V-1 are the parameters examined during the course of this study. Sucker Brook and its tributaries were sampled twice a month from October, 1987 through December, 1988. At the same time, flow measurements were taken and staff gage values recorded. Lake stations were sampled on a monthly basis throughout the study period by VLAP or NHDES personnel.

B. Temperature and Dissolved Oxygen

Webster Lake has the stratification typical for north temperate lakes. It was stratified during the summer months, with the surface layer 10 degrees warmer than the bottom waters by late July (Figure V-I and II-3). Webster Lake had isothermal conditions during spring and fall overturn, and was typically negatively stratified during periods of ice cover. Raw data and additional profiles are compiled in Appendices V-4 and V-5.

Anoxic (low dissolved oxygen) conditions occurred in the hypolimnion of Webster Lake from early July through mid August (Table V-2 and Figure V-1). During this time lack of oxygen was evident from 8 meters to the bottom. Hypolimnetic anoxia is significant in Webster Lake because it allows for release of phosphorus from bottom sediments into the overlying water layer (internal loading). Connor and Smith (1983) estimated that Kezar Lake's nutrient-rich sediments released an estimated 11.3 Kg of phosphorus during August under anoxic conditions. The potential for significant internal phosphorus loading exists for Webster Lake because of the low hypolimnetic dissolved oxygen and the phosphorus enriched sediment. Phosphorus loading is discussed in Chapters VI and VII while sediment analyses are discussed in Chapter VIII.

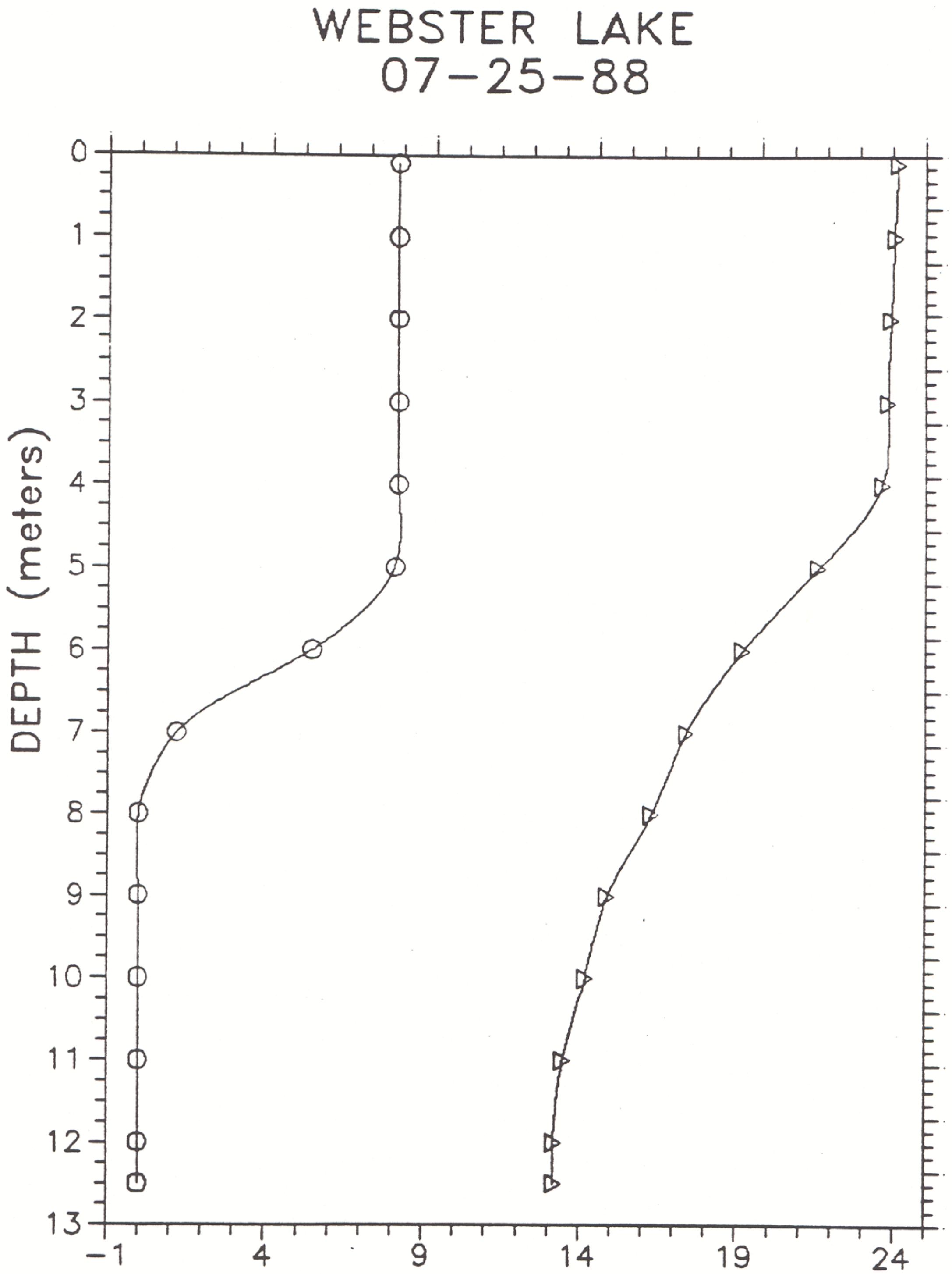

Figure V-1. Dissolved Oxygen/Temperature Profile.

Table V-1.
Sampling parameters for Webster Lake study.

Parameter	Location
Temperature/Dissolved Oxygen	lake
pH	lake and streams
Acid Neutralizing Capacity	lake and streams
Specific Conductance	lake and streams
Chlorides	lake and streams
Sulfates	lake and streams
Color	lake and streams
Total Phosphorus	lake and streams
Nitrate Nitrogen	lake and streams
Total Kjeldahl Nitrogen	lake and streams
Plankton	lake
Chlorophyll-a	lake
Transparency	lake
Turbidity	streams

Table V-2

Bottom Dissolved Oxygen Concentration

Month	Dissolved Oxygen (mg/L)
June	2.75*
July	0.0*
August	1.0

* Mean

C. pH and Acid Neutralizing Capacity (ANC)

The term pH is used to describe the acidity of water. The pH scale ranges from 1 to 14 with 7 being a neutral value. Values below 7 are acidic while values above 7 are basic. The pH scale is logarithmic; each unit change is a 10 fold change; that is, a pH of 5 is 10 times more acidic than a pH of 6. Acid neutralizing capacity (ANC), or alkalinity, is a measure of the capacity of a solution to neutralize or buffer acidic inputs.

The granitic bedrock of New Hampshire contains few buffering materials, and thus the state's lakes have low buffering capacities (ANCs range from 2 to 20 mg/L as $CaCO_3$). New Hampshire's lakes are particularly vulnerable to acid rain.

1. Tributary Data

Values of pH in Sucker Brook and its tributaries ranged from 4.49 on 4/29/88 at Three Brooks Station to 7.44 on 11/4/88 at Reep Farm Station. The lowest median pH value measured during the study period was at Cilley Hill Brook (Table V-3). Cilley Hill Brook also had low color values (Table V-11) indicating the low pH values were not due to natural drainage from wetlands. Seasonal median pH (Table V-3) tended to be highest during the summer. During these months aquatic algae and plants are the most productive, thereby exporting carbon dioxide from the streams and increasing pH. During fall and winter, as productivity declines, median pH generally decreased to minimum levels. Median pH tended to increase slightly from fall to spring, in response to the renewed growing season. However spring mean pH values tend to be depressed by rain and snowmelt events.

Acid neutralizing capacity values for Sucker Brook and its tributaries

Table V-3.
Mean Study Period and Seasonal pH for Sucker Brook and its tributaries.

Station	Study Period	Spring	Summer	Fall	Winter
Highland Outlet	6.74	6.78	6.87	6.65	6.58
Three Brooks	6.68	6.72	6.68	6.68	6.48
Cilley Hill Brook	6.17	6.13	6.35	6.08	6.18
Dyers Crossing	6.66	6.10	6.58	6.53	6.58
Emory Pond Brook	6.82	6.88	6.79	6.80	6.69
Bald Hill Brook	6.55	6.49	6.77	6.64	6.36
Reep Farm Station	6.84	6.74	6.93	9.92	6.82
Apple Farm Brook	6.73	6.70	6.81	6.82	6.56
Webster Inlet	6.85	6.84	7.00	6.88	6.68
Hembirch Brook	7.02	--	--	--	--
Waterfall Brook	6.22	--	--	--	--
Claypond Brook	7.38	--	--	--	--

are presented in Table V-4. ANC data was limited for Hembirch, Waterfall and Claypond Brooks due to their seasonal flow, and was not included in any statistical analysis. The lowest mean ANC values occurred at Cilley Hill Brook and Bald Hill Brook. April ANC values were typically half of those found in October. Snowmelt is considered to be the cause of this decrease. A study on the effect of snowmelt on stream chemistry in New Hampshire indicated that pH and alkalinity followed similar trends during the course of a year, these values were reduced during storm and snowmelt events (Estabrook, 1985). The lower ANC results obtained in October, 1987 compared to October, 1988 attributed are to a rain event of 0.46 inches occurring 3 days prior to the sampling.

Table V-4.
Acid neutralizing capacity (mg/L as $CaCO_3$) for Sucker Brook and its tributaries.

Station	Date 10/14/87	1/14/88	4/14/88	10/14/88	Mean
Highland Outlet	8.00	7.70	6.80	9.90	8.10
Three Brooks	8.20	7.80	6.20	14.20	9.10
Cilley Hill Brook	2.00	2.10	1.00	6.61	3.20
Dyers Crossing	7.60	2.10	1.00	12.70	5.40
Emory Pond Brook	11.30	9.40	7.20	15.00	10.70
Bald Hill Brook	4.50	2.70	2.40	8.40	3.90
Reep Farm Station	9.30	9.40	6.90	21.30	11.70
Apple Farm Brook	9.80	7.00	5.90	18.30	10.25
Webster Inlet	9.40	9.40	7.50	9.50	8.95
Hembirch Brook	--	--	9.90	--	--
Waterfall Brook	--	--	2.80	--	--
Claypond Brook	--	--	--	--	--

2. Lake Data

Planktonic photosynthesis removes carbon dioxide from the lake which causes the pH to rise. For this reason, the photic zone tend to have higher pH values than underlying layers, and the highest surface values are recorded during the summer when phytoplankton populations are at their maximum levels. Values measured during spring and fall overturn are usually similar throughout the water column. In general, Webster Lake illustrated these typical pH trends (Table V-5). In contrast to these typical trends, the April and August, the hypolimnetic pH was similar to the surface value recorded, and was significantly higher than any other bottom pH recorded during the summer stratification season. We have no explanation for this anomalous value. The pH values of Webster Lake are typical of New Hampshire lakes not impacted by acid rain.

In contrast to pH, ANC values are inclined to be higher at the bottom of a lake. This is caused by the release of buffering materials from the lake sediments to the overlying waters. Webster Lake ANC values are representative of New Hampshire lakes.

Table V-5. Acid neutralizing and pH results from monthly sampling of Webster Lake.

Month	pH			Acid Neutralizing Capacity		
	Epilimnion	Metalimnion	Hypolimnion	Epilimnion	Metalimnion	Hypolimnion
Sept 87	6.7	6.74	6.43	--	--	--
Oct 87	--	--	--	--	--	--
Nov 87	6.84	6.54	6.54	6.7	7.5	7.6
Dec 87	--	--	--	--	--	--
Jan 88	6.74	6.38	6.24	7.0	6.8	7.1
Feb 88	--	--	--	--	--	--
Mar 88	--	--	--	--	--	--
Apr 88	6.93	7.01	7.03	--	--	--
May 88	7.09	6.83	6.38	--	--	--
Jun 88	7.13	6.85	6.45	10.6	--	--
Jul 88	7.10*	6.60*	6.36*	7.0	7.0	7.5
Aug 88	7.04	6.85	7.08	7.7	--	--
Sep 88	6.94	6.74	6.75	7.4	--	--
Oct 88	6.85	6.55	6.75	7.3	7.2	7.9

*Median Value

D. Specific Conductance

Specific Conductance or conductivity is a measure of the ability of water to conduct an electrical current. This ability is determined by the amount of ionic particles present in the water. Specific conductance measurements can determine various pollutants in-lake and its tributaries.

1. Tributary Data

As shown in Table V-6, mean study period specific conductance for Sucker Brook and its tributaries ranged from 25.5 umhos/cm (Cilley Hill Brook) to 56.4 umhos/cm (Webster Inlet Station). Conductivity at Cilley Hill and Bald Hill Brooks were similar and had standard deviations (a measure of the variance around the mean) of less than 6.0 umhos/cm during the study period. Emory Pond and Apple Farm Brooks both had specific conductance values of approximately 41.0 umhos/cm, although Emory Pond tended to have less variation during the study. The remaining stations exhibited conductances in the vicinity of 50.0 umhos/cm. The high mean conductivity (209.5 umhos/cm) at Clay Pond station is attributed to the fine clay suspended in the pond's waters.

Mean specific conductance at seven (Highland Outlet, Three Brooks, Dyers Crossing, Reep Farm, Apple Farm and Webster Inlet) of the nine stations, exhibited considerable variability from the study period mean values and significant increases in conductivity during the summer and fall seasons. Each of these stations is close to roadways, and the road runoff is discharged into Sucker Brook. The variability in conductivity at these stations is attributed to this runoff.

2. Lake Data

Table V-7. presents monthly in-lake specific conductance for Webster Lake. Conductivity ranged from 43.13 to 47.72 umhos/cm in the epilimnion, from 43.10 to 48.60 umhos/cm in the metalimnion and from 43.40 to 63.40 umhos/cm in the hypolimnion. All values recorded with the exception of the hypolimnion value of September, 1987 fell within the narrow range between 40.00 and 55.00 umhos/cm. The September, 1987 elevated value occurred during a period of anoxia in the bottom water layer. Other parameters also were elevated during this period, most notably phosphorus, indicating that sediment was releasing ionic particles to the overlying waters increasing the conductivity.

Table V-6.

Mean Study Period and Seasonal Specific Conductance Values for Sucker Brook and its tributaries.

Station	Mean Study Period ± Standard Deviation	Spring	Summer	Fall	Winter
Highland Outlet	50.0 ± 13.0	43.5	43.0	66.6	50.6
Three Brooks	52.0 ± 14.2	42.0	52.6	69.0	49.0
Cilley Hill Brook	25.5 ± 6.0	21.3	27.9	28.5	23.4
Dyers Crossing	50.1 ± 9.5	42.4	56.0	56.9	50.0
Emory Pond Brook	42.2 ± 5.2	38.0	40.6	44.6	43.5
Bald Hill Brook	26.1 ± 4.0	21.7	27.8	30.8	26.0
Reep Farm Station	54.8 ± 12.0	45.4	63.1	64.0	53.0
Apple Farm Brook	41.1 ± 14.6	30.5	58.0	52.3	33.5
Webster Inlet	56.4 ± 12.5	46.4	65.5	66.2	54.4
Hembirch Brook	40.8 ± 3.3	--	--	--	--
Waterfall Brook	30.9 ± 2.0	--	--	--	--
Claypond Brook	210.5 ± 11.5	--	--	--	--

Table V-7.

In-lake specific conductance (umhos/cm) values.

	Conductivity (umhos/cm)		
Month	Epilimnion	Metalimnion	Hypolimnion
Sept 87	44.20	46.00	63.40
Oct 87	--	--	--
Nov 87	45.85	45.80	45.70
Dec 87	--	--	--
Jan 88	47.72	48.60	50.44
Feb 88	--	--	--
Mar 88	--	--	--
Apr 88	43.80	44.30	44.20
May 88	43.13	43.10	44.50
Jun 88	44.20	44.10	43.57
Jul 88	45.42*	45.70*	51.71*
Aug 88	46.95	47.30	47.80
Sep 88	47.38	47.57	47.47
Oct 88	45.70	47.30	47.15

*Median Value

E. Chloride and Sulfate

Chloride levels tend to be below the detectable limit of 2 mg/L in New Hampshire waters that have not been influenced by human activities. Elevated levels are generally associated with road salt runoff or faulty septic systems. Sources of sulfate to New Hampshire lakes are generally related to atmospheric deposition (acid rain) effects. Runoff from fertilized areas may contain elevated sulfate levels.

1. Tributary data

a. Chloride Results

Chloride values for Sucker Brook and its tributaries are presented in Table V-8. Mean study period chlorides ranged from below detection (< 2.0 mg/L at Cilley Hill and Hembirch Brooks) to 26.4 mg/L in Clay Pond Outlet. Seasonal mean chloride concentration was greater at Sucker Brook sampling stations (Highland, Three Bks., Dyers, Reep and Webster Inlet) then its tributaries except Clay Pond. Mean concentration of the tributaries to Sucker Brook did not exhibit the same fall peak. The increased chloride concentration observed are ascribed to fall runoff.

b. Sulfate Results

Presented in Table V-9 are mean sulfate concentrations for Sucker Brook and its tributaries. Mean sulfates ranged from 4.05 mg/L at Emory Pond station to 11.8 mg/L at Clay Pond Outlet. The majority of values tend to fall with the range of 4.0 to 6.0 mg/L, and are typical for New Hampshire waters.

Table V-8.

Mean Study Period and Seasonal Chloride Concentration for Sucker Brook and its tributaries.

Station	Study Period	Spring	Summer	Fall	Winter
Highland Outlet	5.28	4.67	4.40	7.00	5.67
Three Brooks	6.32	4.00	6.40	10.20	5.33
Cilley Hill Brook	<2.00	<2.00	<2.00	<2.00	<2.00
Dyers Crossing	5.61	4.83	5.20	7.33	5.33
Emory Pond Brook	3.00	2.50	3.20	3.33	2.83
Bald Hill Brook	2.14	<2.00	2.87	<2.00	<2.00
Reep Farm Station	5.82	4.67	6.20	7.33	5.50
Apple Farm Brook	2.64	<2.00	4.20	3.17	<2.00
Webster Inlet	5.89	2.97	5.20	8.00	5.83
Hembirch Brook	<2.00	--	--	--	--
Waterfall Brook	2.75	--	--	--	--
Claypond Brook	26.40	--	--	--	--

Table V-9.

Mean Study Period Sulfate Concentration (mg/L)

Highland Outlet	4.94	Reep Farm	4.85
Three Brooks	5.00	Apple Farm	5.06
Cilley Hill Brook	5.22	Webster Inlet	4.76
Dyers Crossing	4.87	Hembirch Brook	5.50
Emory Pond Brook	4.05	Waterfall Brook	5.75
Bald Hill Brook	4.51	Clay Pond Outlet	11.84

2. Lake Data (Sulfates and Chlorides)

Chloride and sulfate data from Webster Lake during the study period was limited (Table V-10). Chloride results ranged from 5.0 to 6.0 mg/L while sulfate values ranged between 4.0 to 4.7 mg/L for those dates sampled. Both chloride and sulfate concentrations from Webster Lake are typical for New Hampshire surface water.

Table V-10. In-lake chloride and sulfate (mg/L) Concentrations.

		Chloride (mg/L)	
	Epilimnion	Metalimnion	Hypolimnion
11/20/87	5.0	6.0	5.0
10/11/88	6.0	6.0	6.0
11/15/88	6.0	6.0	6.0
		Sulfate (mg/L)	
	Epilimnion	Metalimnion	Hypolimnion
11/20/87	6.1	4.0	4.0
10/11/88	4.1	4.1	4.0
11/15/88	4.6	4.7	4.6

F. Apparent Color

Apparent color is a visual determination of the darkness of the water. Tea colored waters (color values greater than 40 cpu) are generally naturally colored from decaying organic matter. Drainage from wetlands tend to have high color values. Iron and manganese can also add color to water.

1. Tributary Data

The mean study period apparent color in Sucker Brook and its tributaries ranged from 9 cpu in Cilley Hill Brook to 42 cpu in Emory Pond Brook (Table V-11). Mean color observed at Cilley Hill and Apple Farm Brooks was lower than observed color at the other monitoring stations. Mean observations in these two tributaries were typically less than 12 cpu. The remaining stations, with the exception of Emory Pond Brook, had similar apparent color that ranged from 15 and 32 cpu. Emory Pond Brook had the greatest mean study period apparent color (42 cpu); this increased color is attributed to the agricultural activities in the sub-watershed. The seasonal tributaries, Clay Pond Outlet and Hembirch Brook, had colors similar to other stations (15 - 32 cpu), while Waterfall Brook's apparent color (9 cpu) was similar to those measured at Cilley Hill and Apple Farm Brooks.

Mean apparent color fluctuated seasonally with precipitation. Color decreased during winter months, and increased slightly during the spring and fall. Mean precipitation during July and August (6.53 and 5.44 inches respectively) contributed significant increases in apparent color during the summer season.

2. Lake Data

Table V-12 presents monthly in-lake apparent color for Webster Lake. Values ranged from 10 cpu in the epilimnion (September, 1987) to 58 cpu in the hypolimnion (July, 1988). Apparent color in the three stratified layers were similar except for the inexplicably high hypolimnetic value in July.

Table V-11.
Mean Study Period and Seasonal Apparent Color
for Sucker Brook and its tributaries.

Station	Study Period	Spring	Summer	Fall	Winter
Highland Outlet	23	21	22	27	23
Three Brooks	25	23	30	26	20
Cilley Hill Brook	9	12	11	9	6
Dyers Crossing	32	27	58	34	19
Emory Pond Brook	42	69	49	46	30
Bald Hill Brook	32	34	45	33	20
Reep Farm Station	29	31	45	30	19
Apple Farm Brook	12	17	13	10	9
Webster Inlet	26	28	38	27	19
Hembirch Brook	17	--	--	--	--
Waterfall Brook	9	--	--	--	--
Claypond Brook	27	--	--	--	--

Table V-12

Monthly in-lake apparent color results

Apparent Color (CPU)

Month	Epilimnion	Metalimnion	Hypolimnion
Sept 87	10	10	---
Oct 87	---	---	---
Nov 87	11	12	12
Dec 87	---	---	---
Jan 88	13	16	16
Feb 88	---	---	---
Mar 88	---	---	---
Apr 88	14	13	16
May 88	14	17	19
Jun 88	12	13	13
Jul 88	11*	14*	58*
Aug 88	12	13	13
Sep 88	13	13	12
Oct 88	14	12	13
Nov 88	13	13	16
Dec 88	---	---	16

*Median Value

G. Tributary Turbidity

Turbidity is caused by the presence of suspended materials in the water. Erosion results in high turbidity values, and turbidity often increases after a storm event. High tributary turbidities result in siltation and in the introduction of phosphorus to a lake.

Mean turbidity during study period ranged from 0.6 ntu in Cilley Hill Brook to 25 ntu at Clay Pond Outlet (Table V-13). All stations, with the exception of Clay Pond Outlet, had low turbidity (less than 3.0 ntu). Stations exhibited a spring increase in mean turbidity which decreased by summer. Presumably this was a result of snowmelt and spring storm events.

Table V-13.
Mean Study Period and Seasonal Turbidity (ntu) for Sucker Brook and its tributaries.

Station	Study Period Mean	Spring	Summer	Fall	Winter
Highland Outlet	1.3	1.1	1.8	1.8	0.7
Three Brooks	1.0	1.2	1.4	0.7	1.0
Cilley Hill Brook	0.6	1.2	0.7	0.4	0.4
Dyers Crossing	1.5	2.0	1.6	1.1	1.0
Emory Pond Brook	1.4	3.0	1.8	0.7	1.0
Bald Hill Brook	1.3	1.3	1.2	0.4	2.3
Reep Farm Station	1.2	3.0	0.9	0.7	0.9
Apple Farm Brook	1.0	2.4	0.3	0.3	1.0
Webster Inlet	1.3	3.0	0.8	0.6	1.1
Hembirch Brook	2.0	--	--	--	--
Waterfall Brook	0.4	--	--	--	--
Claypond Brook	25.0	--	--	--	--

H. Phosphorus

Phosphorus is an essential nutrient for plant growth. In New Hampshire lakes it is the limiting nutrient, which means that the amount of phosphorus in a lake determines the amount of plant growth in the lake. The major purpose of this study was to determine the sources of phosphorus in the Sucker Brook watershed and to develop management practices that will reduce the phosphorus loading to Webster Lake.

1. Tributary Data

The highest mean total phosphorus concentrations during the study period were observed in Emory Pond Brook (25 ug/L) and at Highland Outlet Station (21 ug/L), while the lowest mean concentrations were recorded in Cilley Hill Brook (6 ug/L) and Apple Farm Brook (8 ug/L). The remainder of the monitoring stations' mean phosphorus concentration ranged between 10 and 15 ug/L (Figure V-2).

Seasonally, Emory Pond Brook had the highest mean phosphorus concentration during Spring, Summer and Winter. During the Fall, the highest mean phosphorus concentration was recorded at Highland Outlet Station (Figure V-3). The increased phosphorus concentration measured in Emory Pond Brook are attributed to the agricultural activities within the Emory Pond watershed. Agricultural waste products and fertilizers can significantly increase levels of phosphorus in surface runoff and streams. Highland Outlet Station's marked rise during the fall corresponds to fall overturn in Highland Lake when phosphorus rich, hypolimnetic waters are distributed throughout the water column. All stations exhibited a summer increase in mean seasonal phosphorus concentrations. This increase was due to early summer (June) rain events.

2. Lake Data

Over the course of the study period total phosphorus concentration (Table V-14) in Webster Lake ranged from 4 to 23 ug/L in the epilimnion, from 8 to 22 ug/L in the metalimnion and from 6 to 150 ug/L in the hypolimnion. The total phosphorus concentration of each layer in August was less than July and September results. The decline in August concentration could have been due to increased precipitation during July

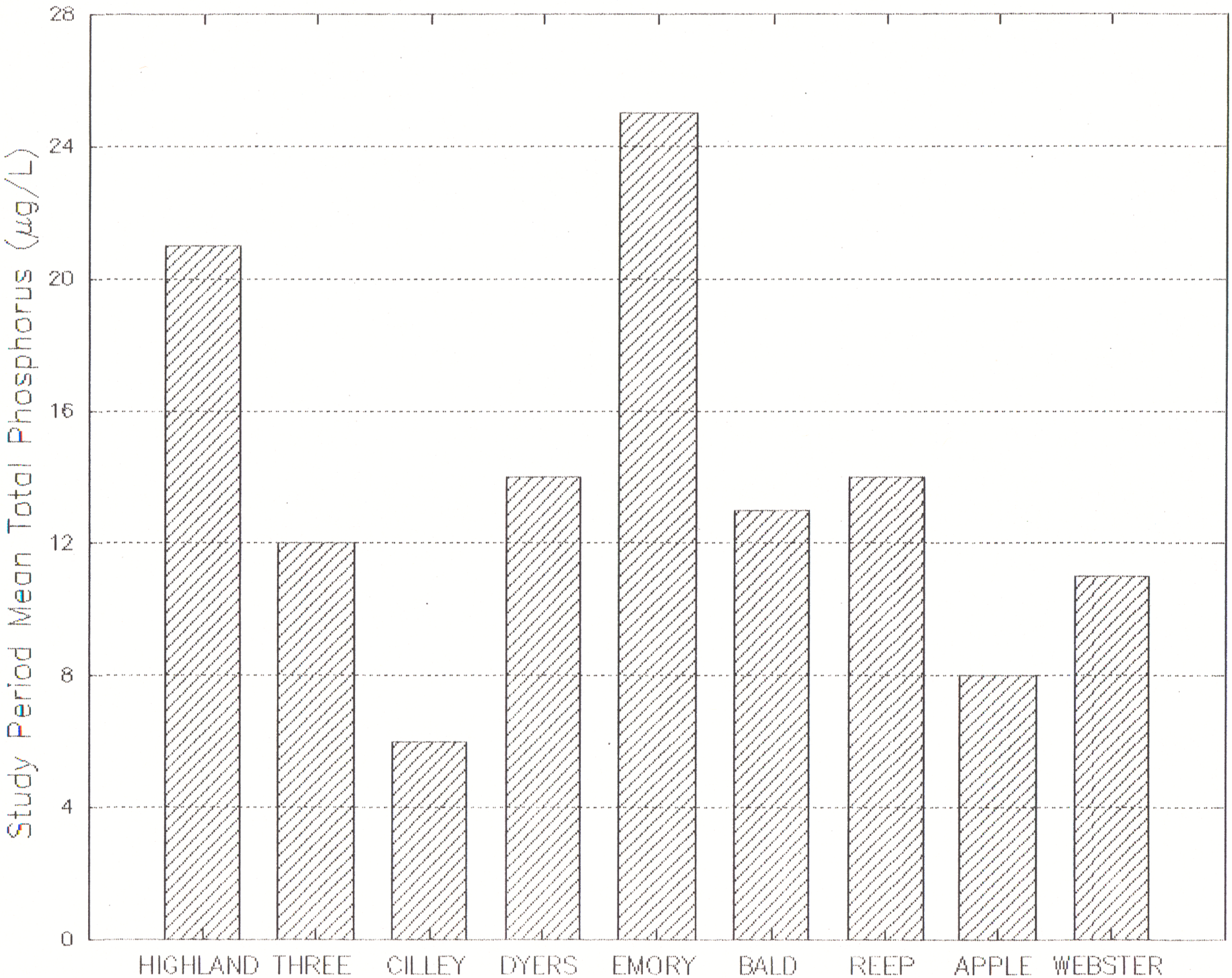

Figure V-2. Mean Study Period Phosphorus Concentration for Sucker Brook and Tributaries.

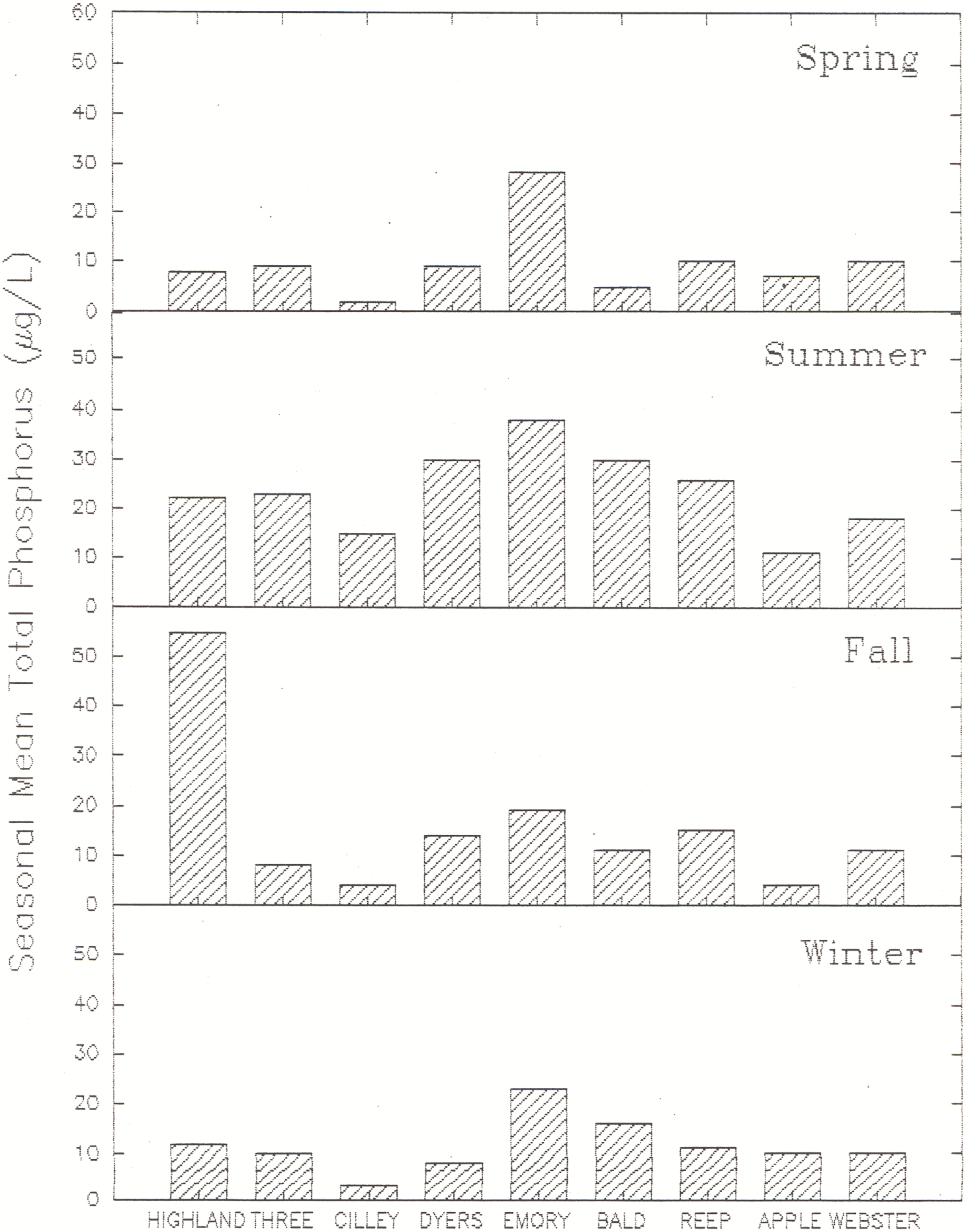

Figure V-3. Seasonal Mean Total Phosphorus Concentrations for Sucker Brook and Tributaries.

and August. July and August precipitation was 5 inches above normal precipitation for the period.

The mean summer (June, July and August) total phosphorus concentration (Table V-15, 1988) observed in Webster Lake during the study period was 11 ug/L in the epilimnion, 12 ug/L in the metalimnion and 25 ug/L in the hypolimnion. These values compare favorably with the New Hampshire mean values of 11, 13 and 20 ug/L for the epilimnion, metalimnion and hypolimnion, respectively. It must be noted that the summer of 1988 was not typical. The usual summer hypolimnetic phosphorus is much higher, having a mean value of 44 ug/L for the years 1987-1990 (Figure V-4).

Extensive total phosphorus data is available for Webster Lake from 1987 through 1990. Summer mean total phosphorus for each stratification layer is presented in Table V-15. This data gives valuable long term insight to total phosphorus trends and concentrations in Webster Lake. Mean annual epilimnetic phosphorus concentration was similar, ranging between a low of 11 ug/L and a high of 14 ug/L. Metalimnetic concentrations also tended to be similar on an annual basis, ranging from 12 to 18 ug/L. In contrast to the upper layers, the mean hypolimnetic total phosphorus concentration fluctuated from year to year. Mean summer concentration ranged from a minimum of 25 ug/L in 1988 to a maximum of 86 ug/L measured in 1980.

Mean summer hypolimnetic total phosphorus fluctuated widely, Figure V-4 illustrates summer concentrations from 1980 and 1987 through 1990. During the summers of 1987 through 1990 concentrations, in general, tended to increase from June to September. This trend was clearly evident in 1987, 1989 and 1990. Another trend was the steady increase in maximum concentration over time; 142 ug/L in 1980, 150 ug/L in 1987 and to date the greatest concentration measured in Webster Lake, 183 ug/L in 1990. This trend is not conclusive, however, because the 1988 and 1989 maximum values were lower (Figure V-4).

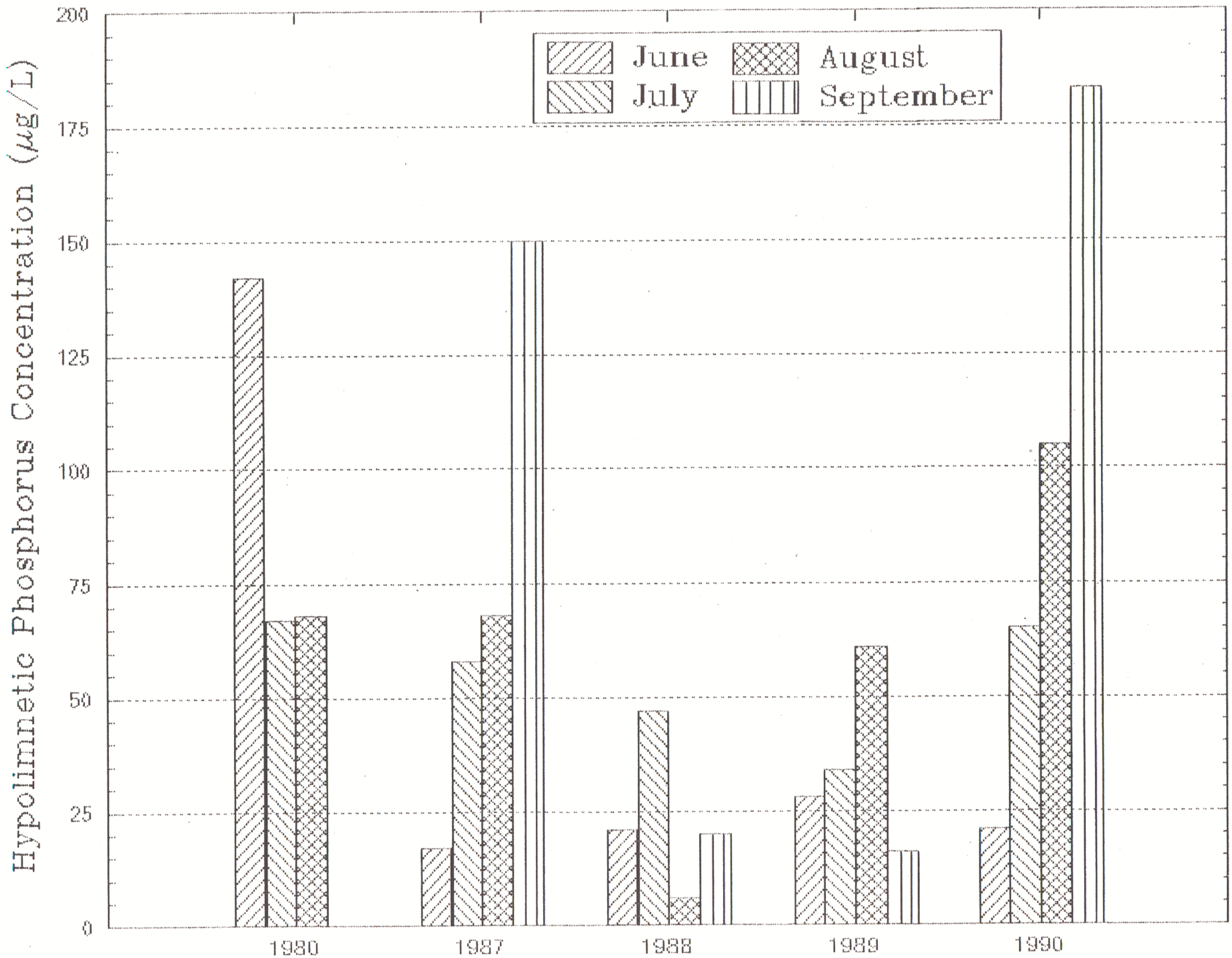

Figure V-4. Mean June, July, August and September Hypolimnetic Phosphorus Concentrations during 1980 and 1987 through 1990.

Table V-15.
Mean Summer In-Lake Total Phosphorus Concentrations.
NHVLAP Data 1987-1990, Webster Lake WQ. Mgmt. Invest. 1980

Layer	1980	1987	1988	1989	1990
Epilimnion	13	12	11	14	13
Metalimnion	16	13	12	18	16
Hypolimnion	86	48	25	41	64

I. Nitrogen (Total Kjeldahl and Nitrate)

Nitrogen, like phosphorus, is an essential plant nutrient but it is not the limiting nutrient in Webster Lake. Two forms of nitrogen were measured: Total Kjeldahl nitrogen measures organic nitrogen (nitrogen contained in plankton and detritus) and inorganic ammonia nitrogen. The oxidization of inorganic nitrogen results in nitrate nitrogen.

Table V-14.

Monthly In-lake total phosphorus concentration.

	Total Phosphorus (ug/L)		
Month	Epilimnion	Metalimnion	Hypolimnion
Sept 87	21	16	150
Oct 87	---	---	---
Nov 87	13	11	18
Dec 87	---	---	---
Jan 88	12	11	14
Feb 88	---	---	---
May 88	---	---	---
Apr 88	12	9	10
May 88	9	9	27
Jun 88	18	14	21
Jul 88	7*	13*	34*
Aug 88	4	8	6
Sep 88	15	16	20
Oct 88	11	11	11
Nov 88	23	22	27
Dec 88	---	---	---

*Median Value

1. Tributary Data

a. Total Kjeldahl Nitrogen

The limited total Kjeldahl nitrogen (TKN) results are summarized in Table V-16. The greatest Mean TKN values in Sucker Brook and tributaries were measured in Emory Pond Brook (0.32 mg/L) and at the Highland Lake Outlet (0.26 mg/L). The lowest TKN concentration (0.12 mg/L) was observed in Apple Farm Brook. The high values are ascribed to agricultural activities occurring in the Emory Pond Brook and Highland Lake watersheds. The Highland Lake TKN concentration also may be greater due to effects of plankton discharged to the outlet.

Table V-16.
Mean Study Period Total
Kjeldahl Nitrogen Concentration (mg/L)

Highland Outlet	0.26	Emory Pond Brook	0.32
Three Brooks	0.20	Bald Hill Brook	0.15
Cilley Hill Brook	0.12	Reep Farm	0.21
Dyers Crossing	0.20	Apple Farm	0.13
Webster Inlet	0.15		

b. Nitrate Nitrogen

Table V-17 presents seasonal and mean nitrate nitrogen over the study period. Mean values were greatest at Emory Pond and Apple Farm Brooks (0.11 mg/L) and are attributed to agricultural activity in the Emory Pond watershed and fertilizer application to Christmas trees in a field bordering Apple Farm Brook. The greatest seasonal nitrate nitrogen results were recorded at Apple Farm Brook during the fall and winter (0.13 mg/L) and during the winter at Emory Pond Brook (0.20 mg/L). Emory Pond and Apple Farm Brooks, both displayed the maximum concentration (0.12 mg/L) during the summer months. Maximum spring nitrate nitrogen (0.17 mg/L) was recorded in Cilley Hill Brook, and is attributed to spring runoff (contaminated with manure) from fields where horses were exercised during the winter months.

Table V-17.

Mean Study Period and Seasonal Nitrate Nitrogen (Mg/L) for Sucker Brook and its tributaries.

Station	Study Period	Spring	Summer	Fall	Winter
Highland Outlet	0.07	0.07	0.07	0.12	0.06
Three Brooks	0.06	0.06	0.07	0.06	0.08
Cilley Hill Brook	0.07	0.17	<0.05	<0.05	<0.05
Dyers Crossing	0.06	0.06	0.05	0.05	0.08
Emory Pond Brook	0.11	0.09	0.12	<0.05	0.20
Bald Hill Brook	<0.05	<0.05	0.06	<0.05	0.05
Reep Farm Station	0.06	0.06	0.08	<0.05	0.08
Apple Farm Brook	0.11	0.06	0.12	0.13	0.13
Webster Inlet	0.07	0.06	0.08	0.06	0.09
Hembirch Brook	0.06	--	--	--	--
Waterfall Brook	<0.05	--	--	--	--
Claypond Brook	<0.05	--	--	--	--

2. Lake Data (Nitrate and Total Kjeldahl Nitrogen)

Webster Lake was sampled twice for TKN and three times for Nitrate Nitrogen. The results of these sampling events are presented in Table V-18. All nitrate results were below the detection limit of the test methodology, 0.05 mg/L. TKN concentration ranged from 0.17 to 0.24 mg/L. These values are typical of New Hampshire lakes.

Table V-18.
Monthly In-lake total Kjeldahl and nitrate nitrogen values.

Date	Total Kjeldahl Nitrogen (mg/L)		
	Epilimnion	Metalimnion	Hypolimnion
Nov 87	0.22	0.28	0.17
Oct 88	0.21	0.21	0.24

	Nitrate Nitrogen (mg/L)		
	Epilimnion	Metalimnion	Hypolimnion
Nov 87	<0.05	<0.05	<0.05
Oct 88	<0.05	<0.05	<0.05
Nov 88	<0.05	<0.05	<0.05

J. Limiting Nutrient

In addition to carbon dioxide, water, and sunlight, all green plants require certain inorganic substances in order to manufacture food through the process of photosynthesis. These inorganic substances are often referred to as plant nutrients.

Phosphorus and nitrogen are the two most important plant nutrients in lake systems for determining the amount of plant growth. Given suitable physical factors, such as temperature and sunlight, the algae in a lake will continue to reproduce until one of the nutrient sources is depleted. This substance is termed the limiting nutrient. Based on the relative abundance of the nutrients required by the algae and the levels commonly found in lakes, phosphorus or nitrogen is nearly always the limiting nutrient. Which of these two is limiting in a given lake can be determined by comparing the concentrations of nitrogen and phosphorus in the water. Sakamoto (1966) stated if the TN:TP ratios were greater than 15 to 17, the lake was phosphorus limited; if they were less than 9 to 10, it was nitrogen limited; and if they were between 10 to

15, a balanced condition existed. The limiting nutrient calculation is most meaningful when applied to surface waters during the summer growing season. Since no summer nitrogen data was collected in this study, data collected during 1980, for the Webster Lake Water Quality Management Investigation (Dufresne-Henry and WS&PCC, 1981), was utilized.

Table V-19 presents the TN:TP ratios calculated for Webster Lake utilizing mean monthly epilimnetic nitrogen and phosphorus values. All TN:TP ratios exceed 15 therefore, Webster Lake was clearly phosphorus limited throughout the summer of 1980. Since phosphorus is the limiting nutrient, any reduction of phosphorus sources to Webster Lake could significantly reduce algae growth and improve lake quality.

Table V-19.
Limiting nutrient in Webster Lake by
comparison of TN:TP mass ratios (Dufresne and Henry, 1981).

Date	Mean Nitrogen (Mean total - Kjeldahl)	Mean Total - P	Ratio TN:TP
June	0.30	0.015	20.0
July	0.26	0.016	16.2
August	0.43	0.008	53.8

K. Plankton

1. Phytoplankton

Phytoplankton are microscopic algae that live in the sun-lit portions of a lake's water column. Whole water phytoplankton includes all sizes while net phytoplankton are only those collected in an 80u mesh net. Phytoplankton density in Webster Lake ranged from 900 cells/mL to 1520 cells/mL (Table V-20). Phytoplankton densities were highest in July and lowest in October, 1988. Webster Lake's phytoplankton densities are typical of those found typically in New Hampshire's mesotrophic (1000-2000 cells/mL) and oligotrophic (0-1000 cells/mL) lakes. (NOTE: colonies, filaments and single cells are all counted as a single standard unit).

Table V-20.
Webster Lake phytoplankton dominance by whole water counts.

Date	Total Density per mL	Phytoplankton SP #per mL % of total	Phytoplankton SP # per mL % of total	Phytoplankton SP # per mL % of total
11/20/87	970	Asterionella	Flagellates	Chroomonas
		425	150	135
		45	15	15
4/27/88	1185	Asterionella	Synedra	Dinobryon
	345	300	75	
	29	25	5	
7/12/88	1520	Tabellaria	Rhizosolenia	Elakatothrix
		330	250	105
		20	15	5
10/11/88	900	Chroomonas	Cryptomonas	Mallamonas
		535	165	50
		60	20	5

The whole water phytoplankton community was commonly dominated by diatoms (Table V-21). During the April and November sampling periods (Table V-20) the dominant phytoplankton was Asterionella and during July, Tabellaria was dominant. Diatoms are typical of New Hampshire's more oligotrophic or mesotrophic lakes. Cryptomonads were dominant during the month of October. Chroomonas made up 59.6% and Cryptomonas 18.3% of the total phytoplankton species. Cryptomonads often become abundant during the colder periods of the year under relatively low light conditions (Wetzel 1975).

Table V-21.
Webster Lake grouped phytoplankton dominance
by whole water counts.

Group	11/20/87	4/27/88	7/12/88	10/11/88
		cells/mL		
Bluegreens	0	0	120.8	0
Greens	172.8	177.1	526.4	64.8
Desmids	4.3	0	0	0
Diatoms	613.4	743.0	768.1	77.8
Cryptomonads	181.4	155.5	60.4	699.8
Chrysophytes	17.3	103.7	43.2	51.8

Phytoplankton from the Cyanobacteria (Bluegreens) were present only in the 7/12/88 sample. A green species, Elakatothrix, composed 6.8 percent of the total whole water community density for that period. Cyanobacteria are commonly associated with eutrophic (high phosphorus concentration) conditions in New Hampshire water bodies. However we find a few bluegreen in oligotrophic waters.

Table V-22 presents net phytoplankton data for Webster Lake. The two diatoms, Asterionella and Tabellaria, were clearly the dominant phytoplankton in Webster Lake. Asterionella was dominant during the fall, winter and spring periods while Tabellaria was dominant during the summer. Tabellaria was co-dominant with Melosira and Asterionella in the fall. Diatoms generally do not become a nuisance to lake users.

Table V-22.
Net phytoplankton data for Webster Lake.

Date	Dominant Phytoplankton	Percent Dominance
11/20/87	Asterionella	90
1/29/88	Asterionella	78
4/27/88	Asterionella	72
7/12/88	Tabellaria	77
10/11/88	Tabellaria	32
	Melosira	30
	Asterionella	23
11/15/88	Asterionella	45
	Tabellaria	50

2. Zooplankton

Zooplankton are microscopic or macroscopic animals that live in a lake's water column. Table V-23 presents the dominant zooplankton genera in Webster Lake. The rotifers, Keratella and Polyarthra, were co-dominant genera throughout most of the sample period. Another rotifer, Kellicottia, was the dominant genera during the spring and were dominant with Keratella and Polyarthra during the fall. Nauplii, Keratella and Polyarthra were dominant during the winter months. Mean rotifer density (107 cells/L) was greater than mean crustacean density (50.5 cells/L) during the course of the sampling period. The types and numbers of zooplankton encountered in Webster Lake were typical of good quality New Hampshire Lakes.

Table V-23.

Zooplankton data for Webster Lake.

Date	Dominant Zooplankton	Cells/L	Grouped Total Density: Rotifers	Grouped Total Density: Microcrustacea	Total Zooplankton
11/20/87	Polyarthra	41	85	41	105
	Keratella	37			
01/29/88	Nauplius Larva	63	81	79	159
	Keratella	52			
	Polyarthra	15			
04/27/88	Kellicottia	70	153	28	181
	Keratella	33			
	Synchaeta	33			
07/12/88	Keratella	44	89	59	155
	Polyarthra	26			
	Nauplius Larva	33			
10/11/88	Polyarthra	46	103	46	148
	Kellicottia	31			
	Keratella	24			
11/15/88	Keratella	65	131	50	190
	Polyarthra	50			
	Calanoid Copepod	37			

L. Chlorophyll-a and Transparency

Chlorophyll-*a* is a measure of the biomass (weight) of phytoplankton in a lake. Secchi disk transparency is a measure of water clarity. Suspended material in the water column, both living and dead, reduces water clarity. Unless large amounts of silt are present, there is generally an inverse correlation between chlorophyll-*a* and secchi disk, so that as the phytoplankton increases, the clarity decreases. This was often the case in Webster Lake (Figure V-5).

Maximum chlorophyll-*a* concentration occurred during October (7.09 mg/m^3) and minimum concentration occurred in August (2.47 mg/m^3) (Table V-24). Above average rainfall during July and August could account for this unusually low chlorophyll-*a*. Maximum transparency occurred in July (4.9 m) while the minimum was observed during November (2.1 m). During the in-lake sampling period (May through November), median chlorophyll-*a* concentration was 6.10 mg/m^3 and the median transparency value was 4.1 meters. These values correspond well to the New Hampshire mean (mesotrophic conditions) chlorophyll-*a* of 6.0 mg/m^3 and mean transparency of 4 meters.

Table V-24.
Monthly chlorophyll-*a* and transparency observations from Webster Lake.

Date	Chlorophyll-a (mg/m^3)	Transparency (m)
May	6.16	3.4
June	6.31	4.1
July	4.87	4.9
Aug.	2.47	4.5
Sept.	4.98	4.5
Oct.	7.09	3.9
Nov.	6.59	2.1
Median	6.10	4.1

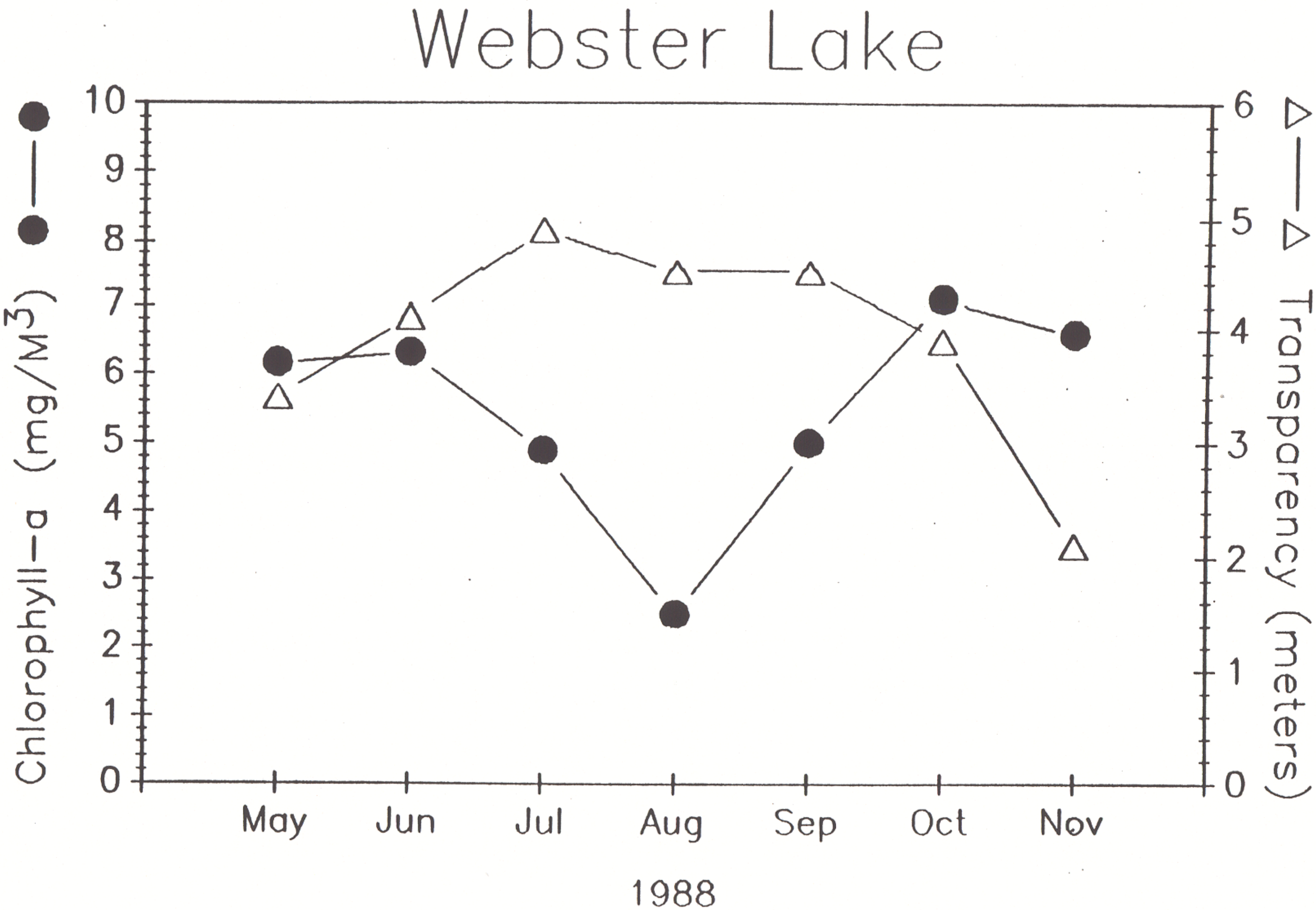

Figure V-5. Monthly chlorophyll-a and transparency for Webster Lake.

M. Vascular Plants

The Biology Bureau of the NH Department of Environmental Services, as part of the Lake and Pond Inventory Program, constructed an aquatic plant distribution and abundance map for Webster Lake in 1979. Figure V-6 and Table V-25 present the results of that survey (Staff Report #121, 1981). No major change in macrophyte distribution and/or abundance was noted during the study period.

The macrophyte community was dominated by Pontederia cordata, pickerel-weed. Overall abundance was considered sparse. Seven genera of other macrophytes were observed at Webster Lake. They were Sparganium, Potamogeton, Scirpus, Nymphaea, Typha, Nuphar and Vallisneria.

N. Fisheries

Webster Lake is currently being managed as a two tiered fishery (warm and cold water species). Investigations by the New Hampshire Fish and Game Department conducted in 1963 and again in 1975 indicate that Webster Lake supported a good warm water fishery (NH Fish & Game unpublished data, 1989). Both surveys found abundant numbers of sunfish and bluegills, white and yellow perch, smallmouth bass and eastern chain pickerel. It was also noted during 1975 that an excellent horned pout population existed at that time.

Fish and Game stocking records for Webster Lake extend back to 1938. During the past 52 years, the lake was stocked with a wide variety of game and forage species of fish (NH Fish & Game unpublished data, 1989). Between the years 1938 and 1976, 30 million smelt eggs, 24,000 horned pout, 5000 smallmouth bass, 3000 black bass, 2,500 golden shiners and 1500 crayfish were stocked. From 1986 through 1988 stocking efforts consisted of 7100 rainbow trout and 4000 brown trout in the one to two year class. No warm water species were stocked during this time. Stocking records from 1976 to 1986 were not available.

O. Storm Event Monitoring

As part of the monitoring program, water quality was sampled during a significant rain event. This occurred September 26, 1989, and when 1.10 inches of precipitation was recorded at Franklin Falls hydroelectric dam. This

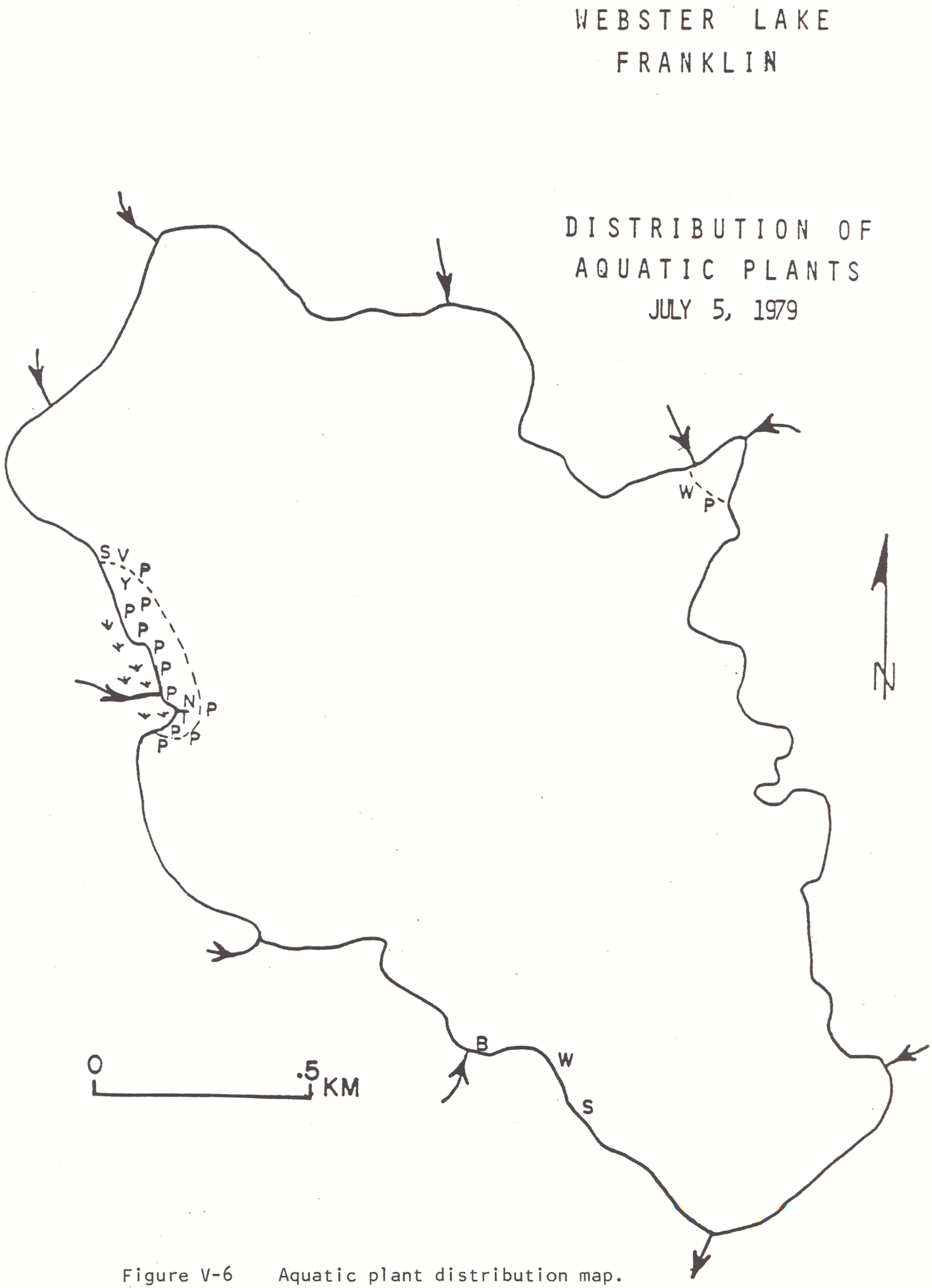

Figure V-6 Aquatic plant distribution map.

Table V-25. Results of Webster Lake aquatic plant survey.

AQUATIC PLANT SURVEY

LAKE: WEBSTER LAKE TOWN: FRANKLIN DATE: 07/05/79

Key	PLANT NAME		ABUNDANCE
	GENERIC	COMMON	
S	Sparganium	Bur reed	Sparse
W	Potamogeton	Pondweed	Sparse
B	Scirpus	Bulrush	Sparse
P	Pontederia cordata	Pickerelweed	Scattered
N	Nymphaea	White water lily	Sparse
T	Typha	Cattail	Sparse
Y	Nuphar	Yellow water lily	Sparse
V	Vallisneria americana	Tape grass	Sparse

OVERALL ABUNDANCE: Sparse

GENERAL OBSERVATIONS:

1. Plants abundant at the Sucker Brook inlet but sparse when the lake is considered as a whole.

site is approximately one mile from the study area. During the rain event the following parameters were measured: stream flow, total phosphorus, turbidity and bacteria. Levels of these parameters can increase because of precipitation washing material into the streams. Turbidity and bacteria levels are discussed below. Stream flow is discussed in Chapter VI and phosphorus loading from storm events is discussed in Chapter VII.

Fecal coliform (Table V-26) ranged from an initial sample of 60 cts/100 ml (Reep Farm) to peak flow level which exceeded 2000 cts/100 ml at six stations (Cilley Hill Brook, Dyers Crossing, Emory Pond Brook, Reep Farm, Apple Farm and Webster Inlet). Counts increased dramatically at four stations (Figure V-7) (Cilley Hill, Dyers Crossing, Reep Farm and Webster Inlet) from counts below 600 to counts exceeding 2000. At two stations, Emory Pond and Apple Farm Brooks, initial counts were somewhat high because of their relatively small watersheds and short water residence time. Peak counts at these two stations also increased to values greater than 2000 cts/100 ml. At three stations, Highland Outlet, Three Brooks and Bald Hill Brook, fecal coliform peak flow results were similar or decreased from initial sample levels.

Turbidity observations during the rain event ranged from an initial minimum level of 1.20 ntu (Webster Inlet) to a maximum of 9.60 ntu (Emory Pond Brook). Peak flow levels ranged from a minimum of 2.20 ntu (Highland Outlet) to a maximum of 12.60 ntu (Emory Pond Brook)(Table V-26). Turbidity increased to varying degrees at all stations (Figure V-8). Values generally increased from values less than 5.00 ntu to within the range of 5.00 to 9.00 ntu. The initial sample collected at Emory Pond Brook exceeded this general range and the peak flow sample increased to 12.60 ntu. Turbidity increases in Emory Pond Brook are attributed to agricultural activity in the watershed. Observations recorded at Highland Outlet did not exhibit the marked increase from initial to peak sample. Turbidity at this station increased from 1.26 to 2.20 ntu. Lakes do not respond to a rain event as a stream would. Water residence time in a lake are high and allow inputs from rain events to be settled out or diluted by the lake's waters. Increases in turbidity evident at the Highland Lake outlet are ascribed to direct bank runoff entering the stream between the lake and sampling station.

Table V-26.
Fecal coliform and turbidity observations from storm event occurring on 9/26/89.

Station	Fecal Coliform (cts/100ml)		Turbidity (ntu)	
	Initial Sample	Peak Flow	Initial Sample	Peak Flow
Highland Outlet	330	90	1.26	2.20
Three Brooks	460	500	1.76	5.50
Cilley Hill Bk.	530	>2000	3.90	8.60
Dyers Crossing	590	>2000	2.40	7.40
Emory Pond Bk.	1780	>2000	9.60	12.60
Bald Hill Bk.	460	400	4.70	7.00
Reep Farm	60	>2000	7.30	7.50
Apple Farm Brook	1190	>2000	3.40	6.00
Webster Inlet	120	>2000	1.20	7.45

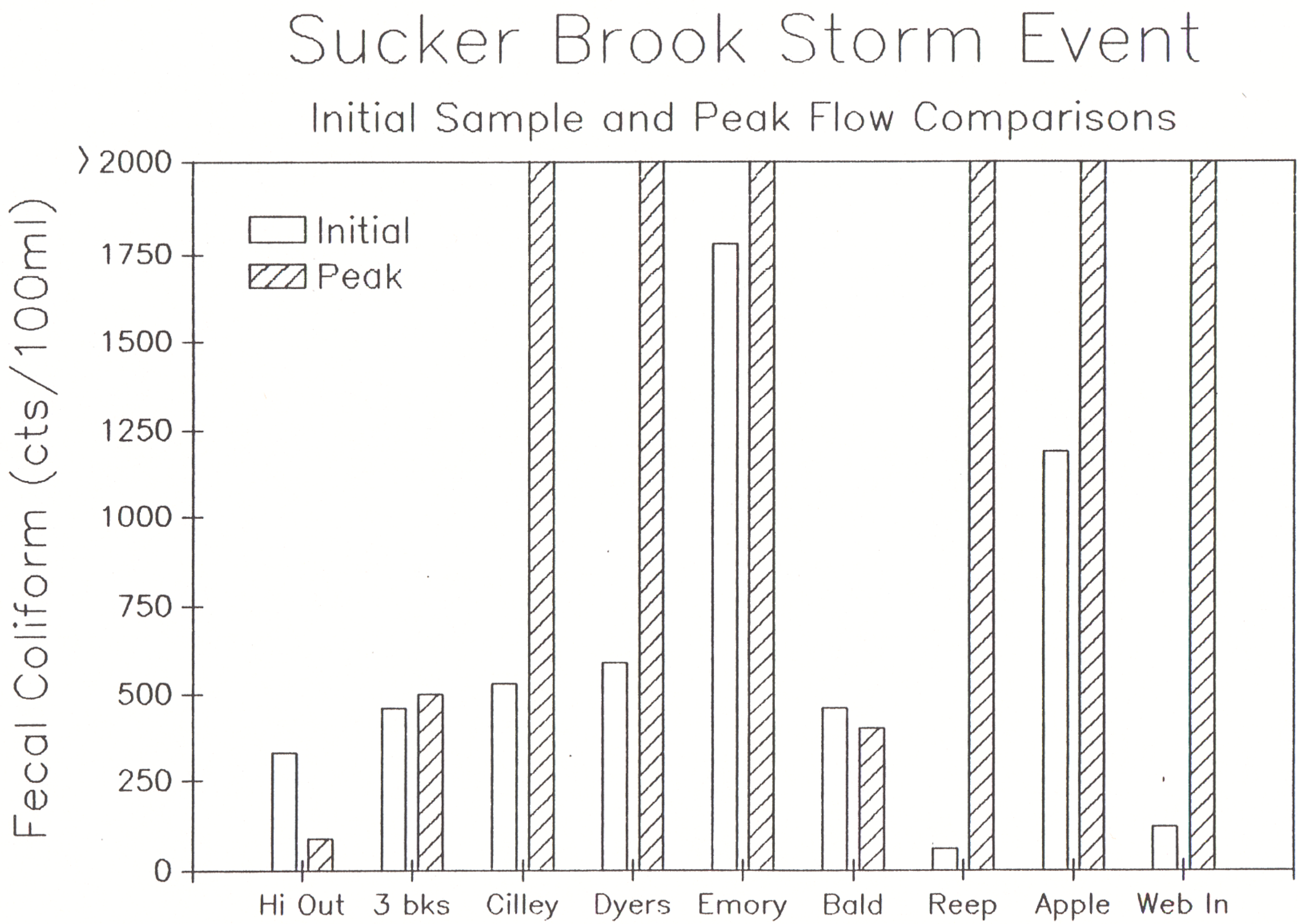

Figure V-7. Initial and peak flow samples taken during a rain event.

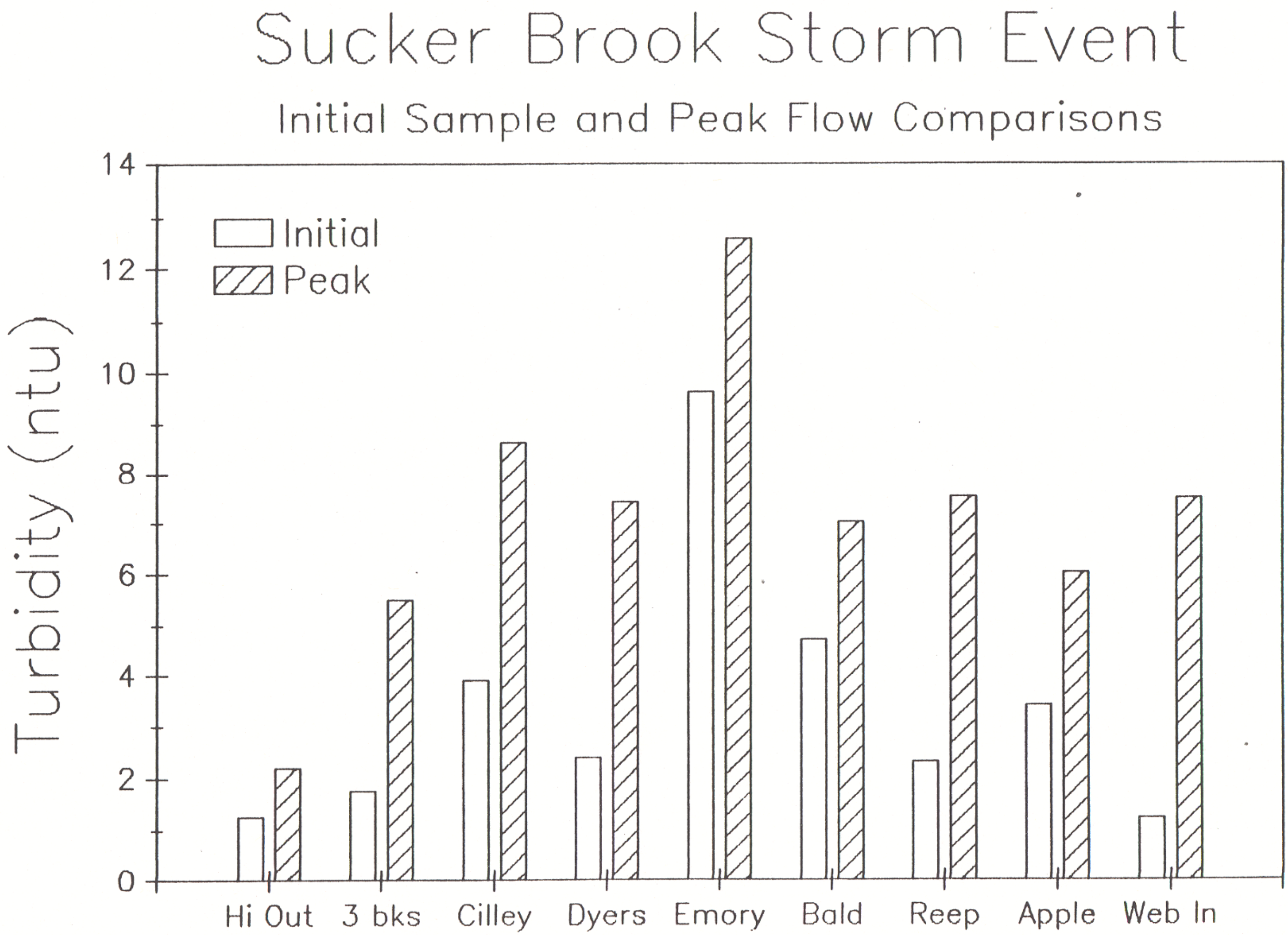

Figure V-8. Initial and peak flow samples taken during a rain event.